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AN EXAMINATION OF ON-SITE WASTEWATER DISPOSAL POLICY IN THE COASTAL ZONE: IMPLICATIONS FOR THE CHARLESTON HARBOR PROJECT AREA

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Abstract

On-site wastewater disposal systems are believed to be responsible for a substantial amount of coastal water pollution. NOAA estimates between 23 and 39% of all shellfish closures in the southern U.S. are attributable to septic systems. Often the adverse effects attributed to septic systems are localized. In such cases, local jurisdictions may be interested in implementing more stringent septic system regulations. Six factors affect whether a local jurisdiction can effectively implement more stringent septic system regulations: (1) Public Attitudes Towards the Land Use Changes Required by New Regulations, (2) The Role of Federal, State and Local Governments in the Policy Process, (3) Technical Uncertainties, (4) Socioeconomic Factors, (5) Adequacy of Resources for Implementation and (6) Whether Regulations are Sound from a Scientific Perspective.

The objective of this master's project is to examine some of the barriers facing local governments seeking to mitigate perceived problems with residential on-site wastewater disposal systems and propose some policy solutions to address these barriers. Specifically, this document: (1) examines the barriers to implementation listed above, (2) reviews policies and programs in 14 state and local jurisdictions to illustrate the range of policy options available and (3) provides a detailed case study of a local area, the Charleston Harbor Project Area, currently considering on-site wastewater policy options; this case study illuminates some of the complex issues that a local jurisdiction must consider when choosing to implement a new septic system policy.

Implementing more effective septic system policies at the local level is a daunting task, specifically because of the adverse effects regulations are perceived to have on land use. Many uncertainties still exist regarding septic system management. It is not likely that these uncertainties will be resolved in the near future. Consequently, decisions will need to made without perfect

information. The most viable option is to make decisions based on considerations of the contamination risks posed by individual systems.

More stringent septic system regulations can be an effective solution to on-site wastewater problems. However, solutions are site-specific. A local jurisdiction needs to consider the political, socioeconomic and environmental impacts of its regulatory decisions before changing its septic system policy.

1. Introduction: Scope of the Problem with Septic Systems and Range of Use in the Coastal Zone

In many coastal areas of the U.S., improperly functioning residential septic systems have been blamed for nutrient, bacterial and viral contamination of ground water, surface waters and shellfishing beds (Sandison et. al. 1992, Taylor 1992, NC DEM 1989, Ehler 1988). For instance, NOAA estimates that septic systems are responsible for between 13% of shellfish harvest closures in the mid-Atlantic to 39% of shellfish waters closed in the Gulf of Mexico (Ehler 1988). In the Southeast, it is estimated that septic systems account for 23%, or 300,000 acres of waters closed to shellfishing (Ehler, 1988). A study in North Carolina estimated that septic systems were responsible for 13% of the shellfish closures in that state (NC DEM, 1989).

These figures are not surprising considering the large number of households in the coastal zone that rely on septic systems for waste water disposal and the amount of waste water individual systems deliver to the soil. For instance, in coastal counties in North Carolina, 58% of all dwellings, or 168,000 households are served by septic systems. In coastal South Carolina, the figure is 25%, or 65,000. (US Census 1990). A septic system serving a household of four delivers approximately 65,000 gallons (250,000 liters) of waste water per year to the soil. If the household is located on an acre lot, this is enough water to cover the entire lot to a depth of 2.5 inches. If eight such households are located on that acre lot, they would produce enough waste water to cover the entire lot to a depth of 20 inches. Because of the volume of waste water produced, septic systems are cited as the leading source, by volume, of ground water pollution (CEQ, 1980).

If the septic systems are sited and designed properly, most of the pollutants within the waste water are removed by the soil. However, if improperly sited, or sited at too high a density, much of this waste water can find its way into the ground water, and from there, migrate into connected surface water bodies.

Because septic systems have been blamed in many cases for coastal water pollution, and because of the potential impacts septic systems can have on ground water and surface waters, some state and local governments have tightened their septic system regulations or upgraded to sewer systems. Many other state and local governments are looking for solutions to perceived septic system problems in their jurisdictions.

Often the problems with septic systems are localized. For instance, contamination of ground or surface waters may be the result of failing or problem systems in a local jurisdiction. If impacted water resources, e.g. shellfishing beds, ground water aquifers, are also located within or border on that jurisdiction, there is incentive for local governments to take action. It may also be the case that a local or regional planning agency concerned with water pollution wishes to encourage local governments to upgrade their septic systems policies (Carlile, 1991). Regardless of the impetus behind a local government's decision to address problems with septic system policy, several constraints affect whether a local government can effectively implement more stringent septic system policies. These constraints include:

(1) Public Attitudes Towards the Land Use Changes Required by New Regulations.

(2) The Role of Federal, State and Local Governments in the Policy Process.

(3) Technical Uncertainties.

(4) Socioeconomic Factors.

(5) Adequacy of Resources for Implementation.

(6) Whether Regulations are Sound from a Scientific Perspective

The objectives of this study are to examine some of the barriers facing local governments seeking to mitigate problems with residential on-site waste water disposal systems and propose some policy solutions to address these barriers. Specifically, I intend to:

(1) Investigate the implications of the first 5 factors listed above for implementing septic system policy at the local level.

(2) Review the scientific literature to determine what constitutes sound policy from a scientific perspective and examine the political obstacles to implementing policies based strictly on scientific criteria.

(3) Review selected state and local policies and programs to provide information about the range of options open to local governments.

(4) Perform a case study of one local area, the Charleston Harbor Project Area, South Carolina, currently looking for solutions to perceived septic system problems and make recommendations for policy change. This case study will serve to illustrate the economic, social and political factors that must be considered in selecting a solution to on-site wastewater problems

The results of this study should familiarize local governments and decision makers with the complex issues involved in setting on-site waste water policy and also illuminate some of the constraints and trade-offs associated with certain policy options.

2. Factors Affecting the Implementation of Septic System Policy.

Batie and Diebel (1992) have characterized the problem with ground water policy in general in the following way: "Gaps in scientific knowledge, scientific controversy and uncoordinated state and federal statutes...pose significant barriers to better management." These same problems, as well as others, confront better septic system management.

I have adapted a framework outlined by Mazmanian and Sabatier (1981) to examine constraints to septic system policy implementation at the local level. Based upon conversations with experts in the field and a review of the literature, I have narrowed the many factors identified by Mazmanian and Sabatier to six specific factors affecting septic system policy. These six factors are presented in Table 1. I examine the first five factors in this section. I find it useful to discuss what constitutes sound policy from a scientific perspective separately. This discussion constitutes section 3 and sets the stage for the review of state policies.

Table 1. Factors Affecting Septic System Policy Implementation

(1) Attitudes Towards Land Use Changes Required by New Regulations
(2) The Role of Federal, State and Local Governments
(3) Technical Uncertainties
(4) Socioeconomic Factors
(5) Adequacy of Resources for Implementation
(6) Sound Scientific Foundation

The Attitude of the Public: Septic System Regulations and Land Use

In unsewered areas, septic system regulations often become de facto land use regulations, specifying where dwellings can and cannot be built. Septic regulations require suitable soil and environmental conditions at a site before a septic system can be installed. If suitable conditions do not exist, an on-site system cannot be put in and the lot cannot be developed. In some cases, a local jurisdiction views the constraints imposed on land use by septic system regulations unfavorably (Montgomery, pers. comm.). In other cases, the results of these constraints are acceptable and even desired by a local community (Lombardo et. al. 1987).

Implementing stricter regulations means, in most cases, requiring more stringent soil and environmental conditions for septic system installation. These more stringent regulations can make land that was previously developable, statutorily unsuitable for building houses or other human habitations. In some jurisdictions, more stringent regulations, because they restrict the number of buildable sites, can limit a jurisdiction's tax base (Rubin pers. comm., Myers et. al. 1991). Because more stringent regulations can limit development and local tax bases, stricter regulations are, in most areas, a politically contentious issue and can face stiff political opposition (Calk pers. comm., Montgomery pers. comm.).

Septic system regulations can often have effects on land use patterns that are desirable to a local community (Lombardo et. al. 1987). Septic systems, because they require, in many cases, a minimum lot size, effectively limit the density of development. Sometimes this limit on density is favored by communities which wish to preserve an exisiting "quality of life". Sewers, which have no such requirements, allow a much greater density of housing units. Septic system regulations in all states reviewed for this paper, with the exception of South Carolina, also forbid the installation of systems on steep slopes and in areas of high seasonal water tables, such as flood plains. In rural areas, regulations have served to keep development off of these fragile areas (Hansen and Jacobs, 1987).

How a community or jurisdiction views septic system regulations, as an impediment to development, or as a tool to protect the environment and quality of life, depends upon the community's collective vision. If a jurisdiction desires rapid, unfettered development, more stringent regulations will probably be contentious. If a jurisdiction wishes to protect an existing quality of life and the environment, tougher regulations will probably not be objectionable.

The Role of Government: Federal, State and Local

The role of state and federal government can influence the ability of a local jurisdiction to implement stricter septic system regulations. Although the federal government is not currently involved in septic system regulations, there are indications that it may become so in the near future. Regulatory activities at the state level may enhance or detract from a local jurisdiction's regulatory efforts.

In this section, I will describe some of the roles played by the three levels of government, federal, state and local, and explore the implications these roles have with respect to implementing septic system regulations at the local level.

The Federal Government

As mentioned in the previous section, septic system regulation often involves land use regulation. For political reasons, other than in rare cases (wetlands and endangered species), the federal government has not involved itself directly in the regulation of land use on private lands (Healy, lecture). Septic systems are no exception. However, the federal government has involved itself indirectly in the management of septic systems in the coastal zone. In 1990, Congress passed the Coastal Zone Management Act Amendments. Section 6217 of the amendments requires coastal states to submit nonpoint source pollution management plans to NOAA and EPA for approval. EPA is assigned the task of creating a set of management measures or guidelines for states to follow regarding the regulation of nonpoint sources such as urban runoff, agriculture, silviculture and septic systems. States are not required to follow EPA's management measures verbatim, but are expected to implement management plans that offer a comparable level of water pollution control (EPA 1993).

EPA published its management measures in 1993 (EPA 1993). States have been encouraged to submit preliminary plans for EPA and NOAA review. This preliminary review or as EPA/NOAA label it, "threshold" review process, is intended to help states understand how sufficient their existing programs are with respect to the dictates of the Coastal Zone Management

Act Amendments and what additional measures are needed before programs will be approved by EPA and NOAA. Thus far, only South Carolina has submitted a plan for preliminary review. (EPA/NOAA 1993). Interestingly, a criticism of existing septic system regulations constituted part of the review. It is unclear at this time what type of changes, if any, EPA and NOAA will require in the regulations of states, such as South Carolina, before the program is approved. The approval process for coastal management plans under the original Coastal Zone Management Act of 1972 was very lenient (Healy, pers. comm.). There have been indications from EPA personnel that the approval process for nonpoint source programs will be much more stringent (Shiles, pers. comm.).

State Government

In most states, policies and regulations for septic system management are set at the state level. Exceptions are Georgia and Michigan, which delegate the responsibilities to local governments. In all known cases in which policy is set at the state level, county and municipal governments are allowed the option of setting their own standards and regulations, provided they are at least as stringent as the state regulations.

State regulatory activities can promote or impede local efforts to implement more effective septic system regulations. In some cases, stringent state regulations can promote the development of comprehensive local programs (Myers et. al. 1991, Carlile 1991). Stringent state regulations can make a large portion of the land in a local jurisdiction statutorily unsuitable for conventional septic systems and development (Myers 1993, Carlile 1991). In order to promote development within their jurisdiction and still meet the requirements of state regulations, the local jurisdiction must often create and implement a comprehensive program (see the description of Kerr County, Texas' program in section 4). These programs typically involve a protocol for the testing and approval of new technologies for use in areas unsuitable for conventional systems and a monitoring, inspection and maintenance program to ensure that new systems and systems currently in use are functioning satisfactorily. Though these programs allow development on previously undevelopable sites, because of monitoring and maintenance activities, they are reported to be even more effective than a traditional program which merely implements the state regulations and uses primarily conventional systems (Rubin pers. comm.). Additional evidence needs to be gathered to determine if this is truly the case.

Lenient state regulations, or lenient enforcement of certain components of state regulations, can make it difficult for a local jurisdiction to implement or enforce stringent regulations (Bartenhagen et. al. 1994). In coastal North Carolina, the state has been very lenient in enforcing its policy regarding the use of innovative technologies. One local health department has taken advantage of this leniency, and is approving for installation technologies not approved by the state. A neighboring health department prefers to interpret the state's regulations conservatively and is pursuing a more stringent policy of not allowing these technologies. The second health department is very frustrated with its efforts to enforce a stringent policy. Residents and prospective land owners are often irate and feel the health department is unfairly prohibiting them from using technologies permitted in "the next county over". It is also generally perceived that the stringent policies are inhibiting development in the jurisdiction and favoring counties served by the more permissive health department. The local health department would like the state to either strictly enforce its regulations regarding innovative technologies or endorse them for state-wide use. In short, the health department wants to only enforce regulations as stringent as those required by the state.

Local Government

As mentioned above, municipal and county governments may be delegated or may choose to undertake the responsibility of drafting their own rules for septic system management. In most cases, however, local governments merely implement the state regulations. They do this with a varying amount of financial support from the state. In some states, local government on-site programs must be completely supported by local funds (Steinbeck, pers. comm.). In others, they may receive state support.

Changing septic tank regulations can be politically contentious because of the impacts on land use. Local governments, because they derive their tax base from property taxes based on the highest and best (monetary) use of a property, are often the level of government most susceptible to development pressures. As discussed in the previous section, it can be extremely difficult for local governments to impose regulations more stringent than the state or another jurisdictions regulations. If the local government does institute a more effective policy, it is usually aimed at implementing technologies and programs which allow development under the constraints of state regulations (Myers et al. 1991, Carlile 1991).

Technical Uncertainties

Two types of technical uncertainties affect a local government's ability to institute new septic system policies: (1) whether to eliminate septic systems altogether and upgrade to sewer and, (2) uncertainties in the amount of pollution septic systems are contributing to local water bodies. I discuss both of these uncertainties below.

More Effective Septic Tank Regulations versus Centralized Sewage Treatment

When facing problems with septic systems, the most common reaction of local governments has been to install centralized sewer (EPA 1985). However, there is evidence to indicate that sewers may not necessarily be the most cost-effective solution (EPA 1985, Lombardo et. al. 1987). Evidence also indicates that sewer systems may not provide clear environmental benefits. The development that may result from centralized sewer may be contrary to the collective goals of the community. Local governments often lack adequate information about the tradeoffs involved in choosing to upgrade septic system regulations or install centralized sewers.

An assessment of the viability of centralized sewer was performed for six barrier islands in North Carolina that had applied for grants to construct centralized sewage treatment plants under monitoring. Each of these studies has its problematic assumptions and limitations. Neither has been able to link septic systems with a certain and specific amount of pollution.

Watershed level studies aim to estimate the contribution of septic systems to the total pollution load of a watershed or water body. The estimates presented in the introduction are the results of watershed level studies. Frequently in these studies, the percentage of failing systems (failing is defined to mean systems where sewage is surfacing and being transported to the waterbody via overland flow) in a geographic area is estimated from local health department data, survey, or expert opinion (Sandison et. al. 1992, NC DEM 1989). This percentage is applied to the total number of households in an area. The pollution load that an individual failing septic system can contribute to a water body is estimated and factored into the equation, and the result is an estimate for total pollution load in a watershed (Sandison et. al. 1992). In some cases, panels of experts may adjust estimates up or down in accordance with the estimates obtained for other sources of pollution in the geographic area of concern.

There are several problems with the watershed level approach. First, the evidence is circumstantial. No tracers or other methods are used to determine if it actually is effluent from septic systems that is polluting local water ways or how much the systems are actually contributing. Though it would seem intuitive that ponded effluent can contaminate water courses, the lack of a "smoking gun" pointing to septic systems is enough to allow governments who would prefer not to change regulations to argue about the accuracy of estimates and the existence of a problem.

Second, only systems which have surfaced and contribute pollution via overland flow are usually considered to have an impact on surface water quality. However, systems which appear to be functioning normally (no ponding of effluent in the front yard) can also contribute to water pollution. If an insufficient amount of soil exists between the bottom of the septic system drainfield and the local water table (which is the case in many coastal areas), a system which to all outward appearances is functioning normally, may be delivering largely untreated waste water to the ground water system (Carlile 1981, Sandison et. al. 1992). If the ground and surface waters in an area are closely connected, as is usually the case in coastal areas, contaminants may quickly find their way into surface waters. Researchers are just beginning to assess the impacts that "normally functioning" systems have on water quality (Sandison et. al. 1992).

Performance monitoring is also used to assess the impacts of septic systems on water quality. The objective of performance monitoring, which is often used to test experimental or innovative systems, is to assess the amount of treatment provided by an individual type of septic system. In a typical study, two or more ground water monitoring wells are located around the septic system at various distances from the drain field. Samples are taken from the wells to monitor the impacts of the system on ground water quality. While this sort of study yields a very credible estimate of the contribution of an individual system to ground water pollution, these studies have several limitations. First, they are site-specific. Usually results can only be applied to systems located in similar soils with a similar ground water table level. Second, and perhaps most importantly, since they do not extrapolate to the watershed level, they do not bring us any closer to having an estimate of the total impacts of septic systems on a water body than watershed level studies. Third, variations in the results of different studies limit their use in determining pollution loads for the purpose of setting policy. Some studies have found substantial impacts on ground water quality (Carlile 1981), whereas others have found little or no effects (Robinson pers. comm.).

The consequence of the uncertainties and gaps associated with these studies is that septic systems have not been convincingly and unquestionably linked to a specific amount of water pollution. A model study to accurately assess the impacts of septic systems would use sewage tracers, monitoring wells and sophisticated hydrologic transport models to accurately measure and predict loading rates from individual septic systems. However, the results of such a study would be specific to the soils and environment in which they are located and to the design regulations under which the septic systems in question were installed. In addition, such a study would be prohibitively expensive. The costs for a performance study in North Carolina which examined 18 innovative systems cost $450,000 (Myers et. al. 1991). Few local governments have the money to devote to this type of study.

There is an exceptional amount of consensus among experts that improperly sited systems (and in most states, a large number of systems sited before the mid 1970's were sited improperly-- see section 3) are a problem (Rubin pers. comm., Perkins 1989, Cogger 1988, Kaplan 1987, Hagedorn et. al. 1981). However this consensus is often not enough to sway some local and state governments to act.

The implications of these problems with scientific evidence is that the decision as to whether septic systems pose a risk becomes political as opposed to a decision grounded in scientific fact. Implementing stricter regulations may make some lands in a jurisdiction undevelopable. Many states and local governments are unwilling to curtail development (Calk pers. comm., Montgomery pers. comm., Hansen and Jacobs 1987). As such, unless presented with direct evidence that septic systems are a problem, they will not change regulations.

It is unlikely that the uncertainties associated with the pollution load from septic systems will be resolved in the near future. Yet decisions will need to be made while uncertainties still exist. Many states and local governments have decided that septic systems are a problem in their area. Instead of focusing their efforts on trying to estimate the actual contributions septic systems make to water pollution in their area, they instead focus on creating a set of regulations that minimizes the risk of ground water contamination from an individual system. Much evidence and consensus exists on the design and siting requirements necessary to minimize the risk of ground and surface water contamination from individual septic systems.

Septic System Problems of A Socioeconomic Nature

Some problems with septic systems are socioeconomic in nature. In the coastal plain of the Southeast, low income households are frequently located in areas unsuitable for septic systems (Rubin pers. comm., Montgomery pers. comm. Grayson et. al. 1982). These areas have either exceptionally high water tables or ponded water on-site for most of the year. Sometimes these households are served by only a pit privy. More frequently they are served by a septic system that is not functioning properly. Grayson et.al. (1982) found that, in the state of North Carolina, septic systems in low-income households were four times as likely to fail as systems in middle and upper income households. Failure was also three times higher for white versus non-white households (Grayson et. al. 1982). Given that low-income households are much more likely to be served by failing systems, it follows that systems serving low-income households are much more likely to contribute to water pollution.

If a local jurisdiction wants to effectively reduce the contribution of septic systems to water pollution, it needs to address septic system problems in its low income communities. In states such as North Carolina, there is currently no formal mechanism or program which provides funds to repair and improve septic systems serving those that do not have the means to pay for the improvements themselves (Rubin, pers. comm.). In addressing problems with septic systems in low income households, it is also important that local jurisdictions do not implement regulations which place an undue economic burden on these households.

Adequacy of Resources

To effectively implement a new policy, a local jurisdiction must have at its disposal the fiscal, human and infrastructure resources to successfully perform all of the activities required by the new policy. The local health department is the administrative unit usually charged with implementation. Examining the resources of the local health department can yield an accurate assessment of the resources a local jurisdiction has at hand to effect a new policy.

Many local health departments do not have the resources to effectively carry out their duties under existing regulations (Steinbeck pers. comm., Nichols et.al. 1990, Kaplan 1987). Local health departments are usually minimally funded and often employ only two to three people to permit septic systems for an entire county, as well as perform other duties (Nichols et.al. 1990). In areas of coastal North Carolina, staff turnover is a problem (Steinbeck pers. comm.). With frequent staff turnover, often there is not an opportunity to build the type of institutional knowledge necessary to run an effective management program.

Implementing more stringent programs will often mean additional duties for local health departments. For instance, some innovative local programs have involved regular inspections of individual septic systems. These additional duties could spread the already spare resources of local health departments very thin. Many innovative programs also involve increasingly complex alternative and experimental technologies. It is possible that some local sanitarians will not be trained in the types of technical knowledge required to administer new programs (Nichols et. al., 1990).

This critique of local health departments should not be applied as a general stereotype. Many local departments are staffed with well educated, energetic and competent people (Myers et. al. 1991, Rubin pers. comm., Calk pers. comm.). Oftentimes the local health department staff is the impetus behind an innovative program (Calk pers. comm.). However, local governments do need to consider the capacity of their health departments and what sort of additional training and resources will be necessary to implement a new program before selecting it.

3. Sound Policy From A Scientific Perspective

From a scientific perspective, a sound policy is one which minimizes the risks of ground and surface water contamination from septic systems. Several design, siting and management factors influence the risks posed by septic systems. These include: density, separation distance between the system and the ground water table, setback distance from a water course, loading rate, frequency of maintenance and regulations regarding systems designed under old regulations which are currently failing. A seventh factor is whether policies are more restrictive near sensitive water bodies or important coastal resources. These seven factors are listed in Table 2.

I find it useful to first review the literature and examine what constitutes sound policy from a scientific perspective and then, to discuss political factors that may cause a jurisdiction to avoid selecting the most scientifically sound policy option.

In discussing scientific evidence and opinions, it should be noted that any quantitative recommendations for regulations apply to the "average" system. I recognize that there is a great deal of site to site variability in the soil and environmental conditions under which septic systems are installed. I am looking for consensus as to what constitutes good rules of thumb for designing and siting systems. Because it is impossible to take into account all possible site variations when creating a new policy, rules which decision makers believe will ensure the safe function of the vast majority of systems in a jurisdiction, are those which are enacted as policy.

Septic System Description

Figure 1 is a schematic diagram of a septic system. Its respective parts are (a) a septic tank which settles out solids from household waste water, (b) a leachline into which liquid effluent from the septic tank flows into (c) a leach field, located beneath the soil. The entire system works via gravity.

Figure 1 is what is termed a conventional septic system. Many variations on this system are possible. For instance, a low pressure pump may be installed to ensure that effluent is evenly distributed across the drain field. Sand or peat pre-filters or a constructed wetland may be installed to pre-treat post-treat effluent. The drain field may be located in a mound which is located above ground to maximize the distance between the leach field and the ground water table. These variations on the conventional septic system are termed alternative systems or technologies.

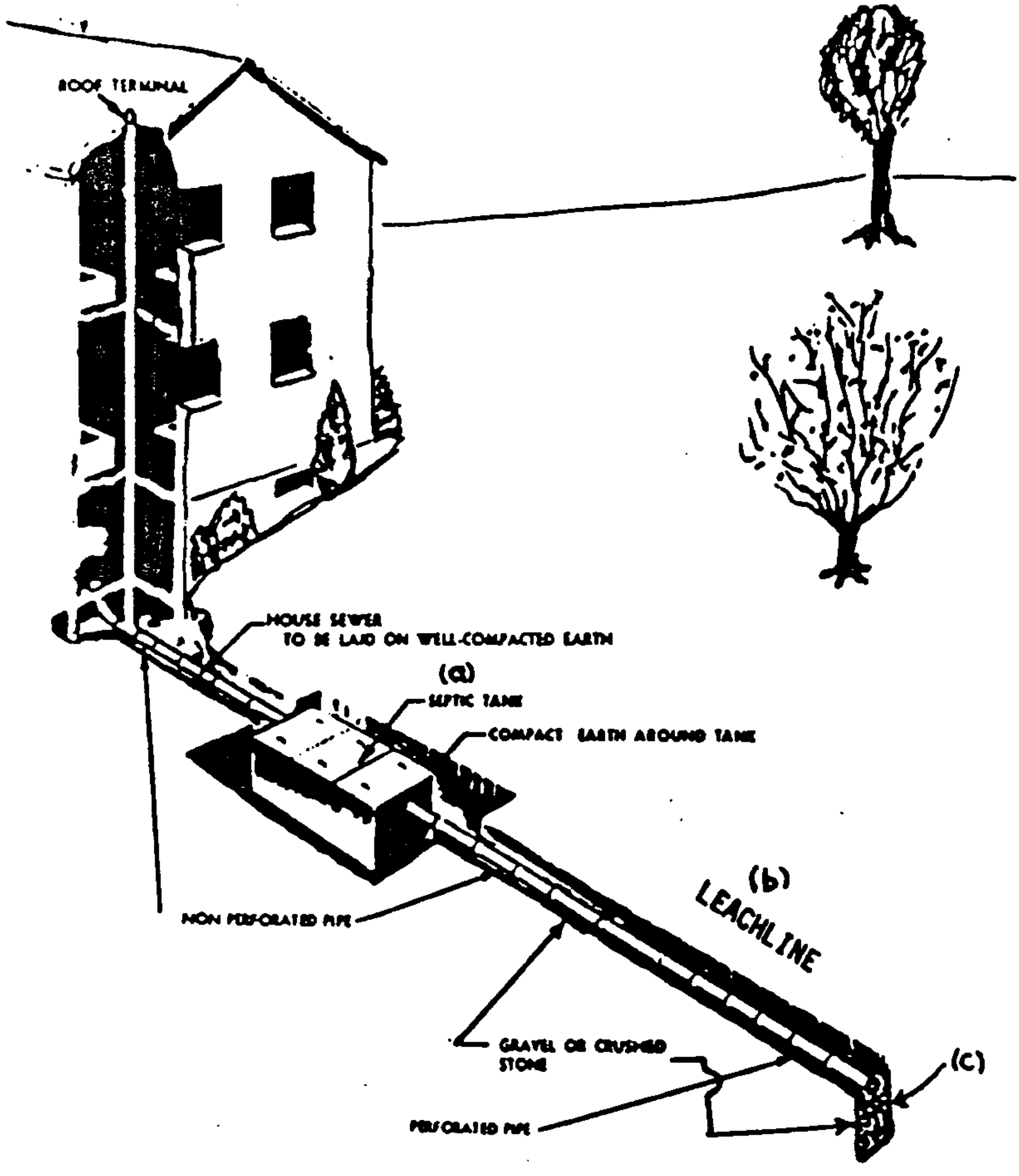
Although the alternative technologies mentioned above are used in all states reviewed for this paper, the conventional system is, by far, the most common system used. Alternative systems are usually used when a site does not meet the criteria necessary for conventional system. Each alternative system usually has its own set of regulations.

I have chosen to review scientific criteria regarding regulations for conventional systems only. I did this for two reasons: (1) Conventional systems are the systems for which basic state regulations are written. They are the most frequently used. (2) Regulations for alternative systems in a state or local jurisdiction are usually permutations of the regulations for conventional systems. If a state's regulations for conventional systems are stringent, its regulations for alternative systems are usually stringent. If a state's regulations for conventional systems are weak, its policy on alternative systems is usually weak.

Table 2. Criteria Influencing the Risks of Contamination from Septic Systems

(1) Density
(2) Separation Between Drain Field and Ground Water
(3) Setback from Water Courses
(4) Loading Rate
(5) Inspection and Maintenance
(6) Regulations Regarding Old Systems
(7) Protection Afforded Sensitive Waters

FIGURE 1. SCHEMATIC OF A CONVENTIONAL SEPTIC SYSTEM



(Adapted from U.S. Public Health Service.)

Scientific Criteria

Density

Ideally, septic systems would be sited at a density based on the carrying capacity of the local environment. That is, septic systems would be sited at a density based on the maximum ability of the soil and ground water ecosystems to absorb the waste water effluent while sustaining only minimal damage (Rubin, pers. comm.). Areas sensitive to pollution would require systems to be located at low density, whereas resilient environments would allow a higher density. While the idea of "carrying capacity" has been used to site systems in some situations (see Section 4 below), the scientific complexity associated with determining carrying capacity has precluded its widespread application. Instead minimum lot size has been used as a proxy.

An effective minimum lot size would be one that minimizes the risk of contamination in all situations in which a system could be installed. Perkins (1984) reviewed empirical evidence and examined the correlation between housing density and ground water contamination. Evidence suggests that between 1/2 to 1 acre is necessary to avoid ground water contamination in most situations, with 1/4 acre possible in some locations. A. Robert Rubin, a professor of biological and agricultural engineering at North Carolina State University estimates that an acre of soil can absorb roughly 200 pounds of nitrogen per year without significant runoff. An individual septic system serving a household of four generates about 50 pounds of nitrogen per year. Based upon these estimates, the absolute maximum density at which systems can be located, excluding the nitrogen load contributed by sources such as atmospheric deposition, natural nutrient cycling and lawn fertilizers, is 4 per acre (Rubin, pers. comm.). Some authors advocate densities much lower than 1 acre per lot (Kaplan 1987).

Density requirements can be quite contentious politically. For example, South Carolina instituted minimum lot size requirements statewide when it rewrote its policy in 1978. This requirement was later dropped from the South Carolina regulations due to staunch political opposition (Calk, pers. comm.)

Separation Distance to Ground Water Table

Separation distance to ground water is perhaps the single most important factor affecting septic system contamination of ground and surface water (Carlile 1981, Hagedorn et. al. 1981, EPA 1993). Dry soil is a hostile environment for bacteria and viruses (Hagedorn et. al. 1981). Unsaturated soil provides a good filter for these organisms. If these organisms reach the ground water table, both their survival and their mobility is greatly enhanced (Hagedorn et. al. 1981). The soil also provides an ionic surface to remove nutrients such as ammonium, nitrate and phosphate.

The separation distance between the bottom of a leach field and the ground water tables should be sufficient enough to attenuate the concentration of bacteria and viruses in waste water so that they reach a safe level before effluent is delivered to the ground water. Cogger (1988) reviewed the literature on the subject. He found that studies show that most bacteria and viral material is removed within the first 12 inches of soil, with 12 to 36 additional inches needed to remove all bacteria and viruses. It should be noted that the attenuation of bacteria through the soil decreases exponentially. The amount of filtering provided by 6 inches of soil versus 12 inches of soil is much more substantial than the difference between 24 and 48 inches. That first 12 inches of soil is the most critical (Cogger, 1988).

In addition to Cogger's study, there is a broad consensus among experts that safe separation distances fall between 24 and 48 inches (Rubin, pers. comm., EPA 1993, Perkins 1989, Cogger 1988, Kaplan 1987), with some authors claiming evidence suggests distances of almost five feet (Peterson and Ward, 1985).

While separation to ground water may be the most important siting requirement with respect to minimizing ground water pollution, it is also the most contentious requirement, especially in the Southeastern coastal plain (Montgomery pers. comm. , Calk, pers. comm.). In many areas of the Southeast, the water table is at or near the surface for most of the year. North Carolina has a minimum separation distance of 18 inches. Even though this requirement does not meet the distances suggested by experts, it still resulted in 94% of the land in a coastal county (Craven Co.) being unsuitable for development (Myers et. al. 1991). As one public health administrator put it, raising the separation distance to 36 inches (the amount recommended by EPA in its management measures under the Coastal Zone Management Act Amendments) would effectively outlaw septic systems in the coastal plain (Montgomery, pers. comm.). While this statement may be slightly hyperbolic, it underscores the dramatic effects changing separation distances is perceived to have on land use.

Setback from Water Course

Oftentimes, even with an adequate separation distance to ground water, it is inevitable that bacteria and viruses will find their way into the ground water. When they do, it is essential that they are detained long enough so that they perish before being delivered to a surface water body. Fifteen to twenty days is considered a sufficient detention time (Rubin, pers. comm.).

The amount of time organisms are detained before being delivered to surface waters is a function of the distance between the drain field and surface water, the slope of the terrain and the hydraulic conductivity of the soil. These factors vary geographically. In the Southeast coastal plain, soils are coarse, allowing rapid ground water movement. However, the terrain is flat. Fifty feet is considered sufficient to detain organisms for fifteen to twenty days (Rubin, pers. comm.). On steeper slopes, ground water can move much faster. Rahe et. al. (1978) found that bacteria moved as much as 150 feet per day during a rainstorm on a hill slope in Oregon. Similarly, in the Southeast, systems located on large sloping dunes may require a substantially larger setback from coastal waters.

Loading Rate

Loading rate is important for two reasons. First, a low loading rate ensures that the delivery rate of effluent to the soil will not exceed the soil's capacity to absorb it and that effluent will not rise to the surface. Second, the lower the loading rate, the less concentrated will be the effluent delivered to a particular piece of soil, and the greater the amount of contaminant removal.

EPA recommends a loading rate between 0.80 and 1.20 gallons per square foot per day on coarse soils. Lower loading rates will provide superior filtration and treatment.

Operation and Maintenance

Even if a system is properly designed and sited, if not operated and maintained properly, there is a risk of systems failure and contamination (Hoover, 1992). The most important maintenance operation is regular pumping of the septic tank. Infrequent pumpings can lead to clogged drain lines and backed up or surfacing sewage. EPA recommends pumping systems every 3 to 5 years.

Regulations Regarding Old Systems

All the state regulations reviewed in this paper were rewritten or amended in the last 10 to 15 years. These new policies are more stringent and are frequently based on sound scientific criteria (State of Maine, 1983). Before this time, regulations were often very lenient and often not scientifically sound. For instance, in South Carolina prior to 1978, no regulations existed regarding separation distance between the drain field and ground water, minimum set back from water courses or density. As a consequence, prior to 1978, systems were sited without regard for these criteria (McCall and Meadows, 1988).

Although no research has been done on the subject, it is intuitive that septic systems installed under more lenient polices would have a higher chance of failing or contributing to ground and surface water pollution than those installed under more stringent regulations. An effective septic system policy should successfully address problems that result from systems installed under more lenient regulations. Two policy options are available.

The first option requires the owner, in the case of failure (failure here meaning obvious malfunction such as ponding effluent or outfall into a water course), to "upgrade" the system so that it meets the design and siting requirements of the new regulations. If it is not possible to meet the requirements of the new regulations because of soil or environmental conditions at the site, the jurisdiction may require the installation of an alternative system. If no on-site solution is possible, the owner may be required to abandon the system and instead use a holding tank and pay costs for regular pumping.

A second policy option is to simply require that the owner perform any repairs necessary to correct the problem, whether the problem be ponding of effluent, sewage backup, or outfall into a water course. Any means are permitted, regardless of existing site conditions. The system is not required to be upgraded to meet current regulations unless other, less expensive repairs fail.

Each of these policies has its strengths and weaknesses. The strength of a policy requiring upgrade is that it brings the failing system into compliance with current, more scientifically sound policy. Systems in compliance with more stringent regulations are less likely to exhibit the types of failure that merited health department attention in the first place. They are also less likely to contribute to ground and surface operation in their day to day operation. It was mentioned that researchers are beginning to pay attention to contamination from systems that appear to be functioning normally. Bringing these systems into compliance with current regulations will reduce the likelihood of this type of pollution.

A disadvantage of a policy requiring upgrade is that it is expensive and can require repair and replacement expenses that are beyond the means of lower income households (Rubin, pers. comm.).

However, a policy requiring only repairs to correct existing problems may not remedy the larger problem, which is that the septic system was improperly designed and sited, given the environmental restrictions of the site. This policy has an advantage, however, in that it offers low cost options to low-income households. A low-income household need only perform repairs necessary to abate the existing problem and need not, unless absolutely necessary, overhaul the entire system.

Tradeoffs between Siting and Design Factors

The six factors described above are interdependent with respect to minimizing septic system risk. For instance, on densely developed sites, where the risk of contamination is high, each of these standards should be followed stringently to minimize risk. However, consider an isolated home site, on a twenty acre lot, 1/2 mile from the nearest water course. Distance to ground water is probably not as critical as it would be under more restrictive conditions. Of course, thought must be given to the future shape of development (i.e. will this one day be the centerpiece of a half acre lot subdivision?). Consider as well a site with good soils, where the depth to ground water is seven feet and where all systems have large drain fields. A density requirement is probably not as critical.

The most efficient policy would take into account not only the interdependency of siting factors, but the severity of the possible outcomes of contamination. Such a policy would allow more lax restrictions in areas where the potential of contamination from septic systems is low and much more stringent regulations where density or the potential for systems to undesirably impact local waters is high.

Protecting Important Coastal Resources

Taking the argument just presented a step further, one could say that an efficient policy would enforce more stringent regulations where important coastal resources, such as shellfish beds and coastal freshwater ponds, are involved, and the status quo elsewhere.

4. Review of Selected State Policies

I have split the 13 coastal states into two groups: Southeastern states and other states. Separating the Southeastern states from the rest of the group is instructive, as it allows the investigation of policy variability within a region. Treating the Southeast separately also helps to create a context for the case study I examine in part 5, on-site waste water policy in the Charleston Harbor Project Area, South Carolina.

I review each set of state regulations with respect to the seven criteria identified in Table 2. I have also compared each group of regulations with the management measures suggested by EPA in *Guidelines Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* (EPA, 1993). A list of each state's published rules is included in the appendix.

After reviewing regulations with respect to the criteria, I provide short synopses of some interesting features contained in selected state regulations.

Southeastern States

Originally I chose the seven coastal states comprising EPA's Region IV (Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina and Virginia) to represent the Southeast. Georgia was then excluded because it has set no state standards, but instead leaves counties to set their own standards.

While choosing a set of states outside the Southeast for the second part of this state review section, Texas was suggested by a staff member at EPA's Small Flows Clearinghouse as a state that had enacted some innovative state policies (Angoli, pers. comm.). Because of the similarities the Texas coast shares with other coastal areas in the Southeast, I have included it in this section. Table 1 displays regulations for the Southeast with respect to the seven criteria listed above.

Lot Size

The states vary considerably with respect to the minimum lot size required for the installation of a conventional septic system. North Carolina, Mississippi, South Carolina and Virginia require only enough space so that a drain field, plus a replacement area in case the first drain field fails, can be located on the property. Each of these three states require that the replacement area be located such that it meets all the suitability and location criteria (i.e. depth to ground water, water body setback) required of the original drainfield.

Alabama and Florida each require lot sizes of between 1/4 and 1/2 acre. Larger lot sizes are required when drinking water is provided by a private well as opposed to a public drinking water supply system.

Texas has the most stringent lot size requirements, requiring 1/2 acre lots with public water supplies and 1 acre lots with private wells. In its regulations (Section 285.11), the state holds that density of septic systems is the factor most responsible for ground and surface water pollution. Stringent lot size requirements are an effort to mitigate and reduce the risk the state perceives to be associated with high densities of systems.

Given empirical evidence and the opinions of experts, the Alabama and Florida regulations probably offer an adequate amount of protection. The Texas regulations offer superior protection, whereas the North Carolina, South Carolina, Mississippi and Virginia regulations allow for a density of development that may lead to excessive nutrient, bacterial and viral loading of ground and surface water systems.

TABLE 3. Conventional Septic System Regulations for Selected States in the Southeastern U.S.

	LOT SIZE**	DEPTH TO GROUND WATER	WATER BODY SETBACK	LOADING RATE++ (gpd/ sq ft)	POLICY ON OLD SYSTEMS	INSPECTION AND MAINT	SPECIAL COASTAL PROTECT
ALABAMA	15,000 sq.ft. 20,000 sq.ft.	18"	50'	1.21 (5 mpi) 0.88 (15m/i)	No Upgrade	No	No
FLORIDA	1/4 acre[f] 1/2 acre	24"	75'	1.25 (5 m/i) 0.75 (15m/i)	Upgrade	No	No
NORTH CAROLINA	drain field + 100%	18"	100' (SA) 50'	1.20-0.80 (all sands)	Upgrade	No	No
MISSISSIPPI	drain field + 50%	12"	100'	1.20-0.80 (all sands)	No Upgrade	No	No
SOUTH CAROLINA	drain field	6"	50'	1.20-0.80 (all sands)	No Upgrade	No	No
TEXAS d. + load restr.	1/2 acre 1 acre	36"	75'	0.60 (5-15 mpi)	Not Specific	No	No
VIRGINIA	drain field + 50%	2-3"	50' or 70'	0.91 (5 mpi) 0.75 (15m/i)	No Upgrade	No	No
EPA SEC. 6217 RECOMM.	site-specific	36"	50-100'	1.20-0.80 (all sands)	Not Specific	Yes	Yes

** when two numbers are displayed, the first is the lot size required when lots are served by public water supply. The second refers to lots served by private wells.

++ the regulations determine loading rate by one of two methods: textural classification and percolation rate. Loading rates determined by textural classification are shown for sandy soils. Loading rates determined by percolation test are shown for percolation rates between 5 and 15 minutes per inch, which is the expected percolation rate for sandy to loamy soils.

Depth to Ground Water

The amount of unsaturated soil between the bottom of the drain field and the ground water table is often cited as the most critical factor affecting the contribution of individual septic systems to ground water pollution (Cogger 1988, Carlile 1985). Most researchers feel that between 24 and 48 inches is necessary to remove all bacteria and nutrients from septic effluent (Rubin pers. comm., EPA 1993, Perkins 1989, Cogger 1988, Kaplan 1987).

Florida and Texas both meet the suggested 24 to 48 inch separation distance. Mississippi requires only a foot of separation. Alabama and North Carolina fall in between these two groups with a separation requirement of 18 inches. South Carolina and Virginia require only a 6 inch and 2-3 inch separation distance, respectively (note: Virginia requirements are for coarse sands in the coastal plain). EPA suggests a 3 foot separation distance.

Given the recommendations of experts and Cogger's (1988) review of literature on the topic, it would seem that Florida and Texas provide sufficient separation distances to prevent bacterial and viral material from entering the ground water. Alabama and North Carolina's 18 inch requirement and Mississippi's 12 inch requirement may result in some bacterial and viral material being transmitted to the ground water. South Carolina and Virginia's regulations are clearly inadequate to prevent ground water contamination.

As mentioned in the introduction, separation requirements to ground water table has the potential to have the greatest impacts on land use. In many areas of the Southeastern coastal plain, the water table is high. The larger the separation distance, the smaller the number of developable sites. Consequently, separation distance can be quite a contentious issue (Robinson pers. comm., Montgomery pers. comm.)

Water Body Setback

All states meet the suggested 50' setback. North Carolina and Mississippi provide for the most protection with a 100' setback requirement.

Loading Rate

EPA suggests a loading rate of between 1.2 and 0.8 gallons per square foot per day in coarse soils to prevent sewage surfacing. All of the states meet this suggestion. Texas and Virginia opt for rates lower than that suggested and thus provide for more effective contaminant removal.

Maintenance and Operation Requirements

None of the states in the Southeast has any maintenance or operations requirements. Maintenance and operation is left up to the individual homeowner. North Carolina performs periodic inspections of larger on-site systems and alternative residential systems and requires that these systems be operating effectively at the time of inspection. Conventional systems, however, which make up the bulk of residential systems in the state, are not included in this maintenance and inspection program.

Regulations Regarding Systems Installed Under Existing Regulations

North Carolina and Florida require malfunctioning systems to be upgraded to meet current policy. All the other states require only an abatement of the problem.

Special Coastal Protection

None of the states in the Southeast provides additional measures for the protection of resources of critical concern, such as wetlands and ponds, nutrient sensitive waters, etc.